US Climate Modeling Summit

Annual event centered on capabilities of the six major federally funded climate model centers:

DoE, NASA-GISS, NASA-GMAO,

NOAA-EMC, NOAA-GFDL, NSF-NCAR

Date: April 3-4, 2019

Co-chairs: Steve Pawson (NASA GMAO) and Gavin Schmidt (NASA GISS)

Modes of Variability Workshop

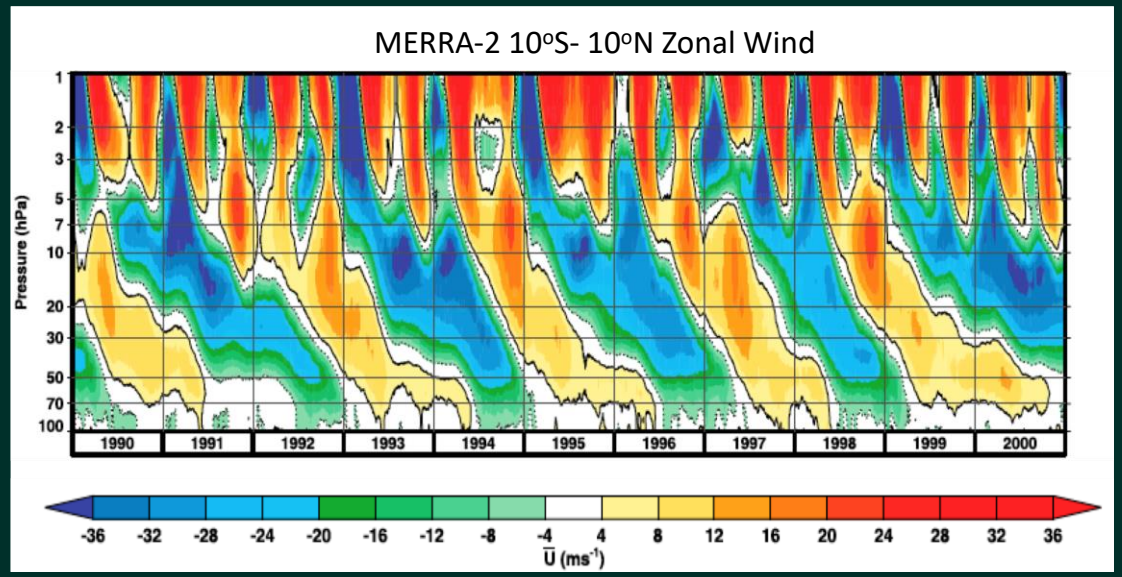
- Summary of state-of-the-art in defining key modes of variability (from sub-monthly to decadal timescales)
- Reports from experts on improvements in model skill and remaining challenges
- Tropical modes/Extra-tropical modes + teleconnections
- Interactions btw modes
- Impacts of climate change

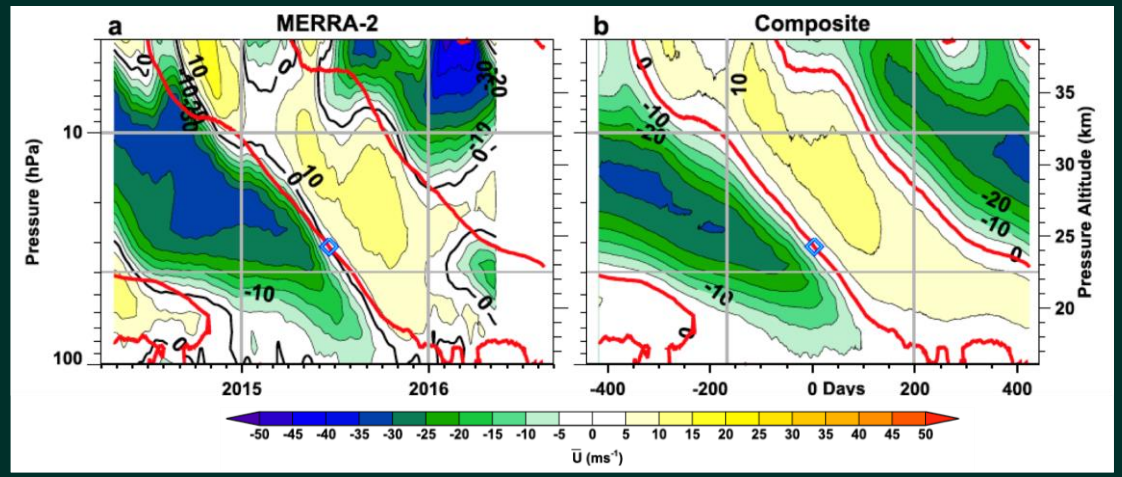
Modes of Variability: Scope

Table 1: Mode	Timescale	Location	Diagnostics
North Atlantic Oscillation/ Arctic Oscillation (NAO/AO)	7-60 days	Northern High Latitudes (Atl. Sector)	SLP
Madden-Julian Osc. (MJO)	20-80 days	Tropical Pacific	OLR, Precip (Daily)
El Niño/Southern Osc. (ENSO)	3-7 years	Tropical Pacific	SST, OLR, Water vapor, Precipitation
Quasi-Biennial Osc. (QBO)	2-3 years	Trop. lower stratos	U-wind
Southern Annular Mode (SAM)	7-60 days	South. High Lat.	SLP, U-wind
Pacific Decadal Osc. (PDO)	5-15 years	Pacific Ocean	SST

Clara Orbe - QBO:

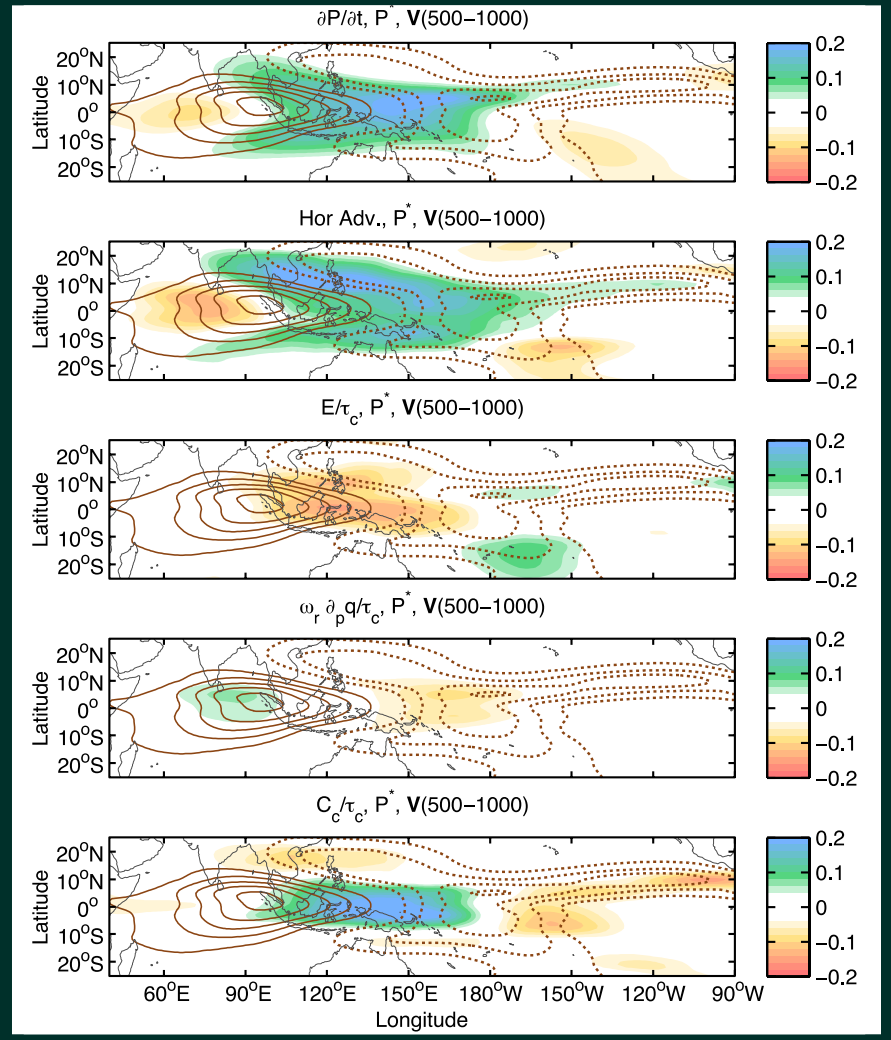
- QBO simulations improved in recent years
- Some difficulty in simulating how far down zonal wind signals propagate, which may influence ability to simulate QBO-MJO connection
- Dependence on GWD parameterization limits models' ability to simulate QBO response to warming
- Sensitivity to vertically integrated momentum flux, so changes in convection parameterizations require retuning
- Non-hydrostatic model may be helpful for simulating gravity waves and hence QBO
- Limited understanding of volcanic forcing on QBO behavior
- Limited understanding of the QBO disruption that occurred in 2016 (it was not well predicted)



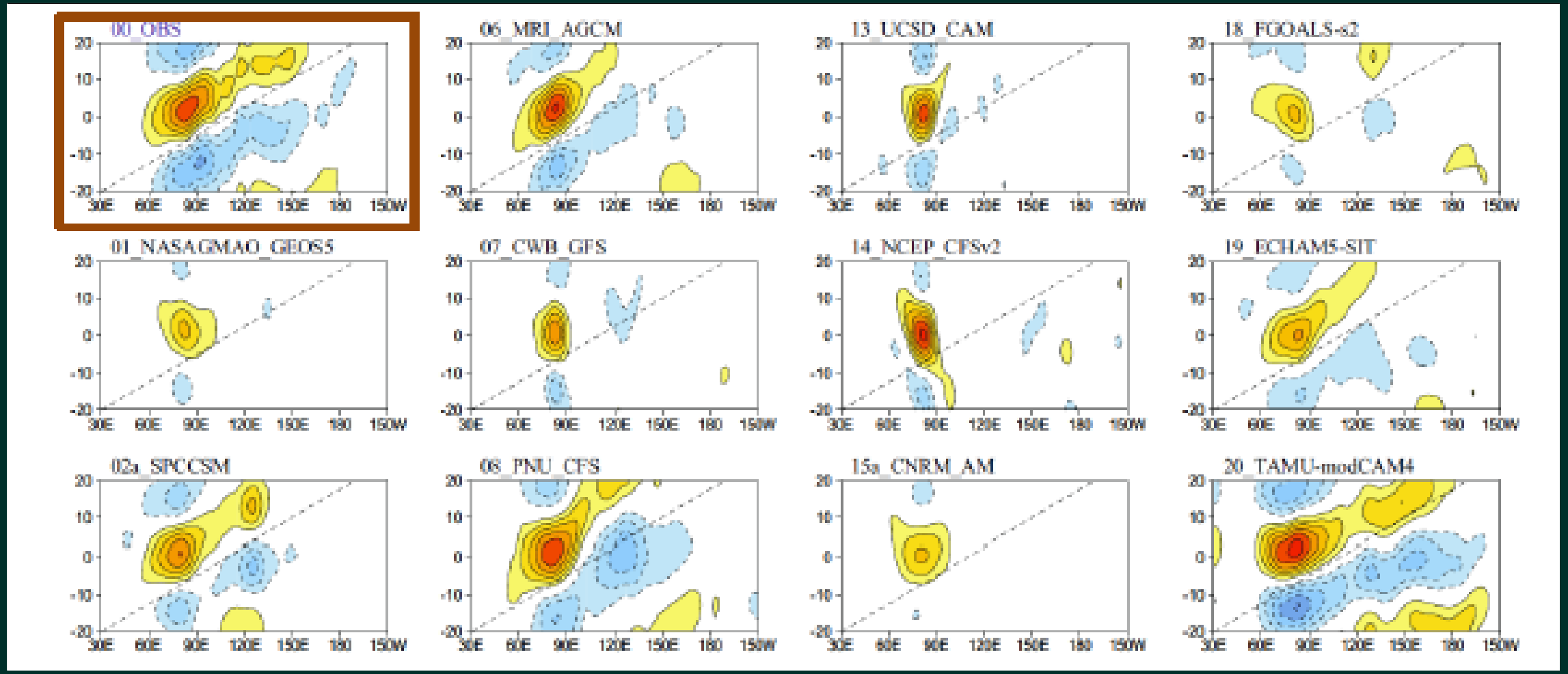


Angel Adames - MJO:

- Improvements shown from CMIP3 to CMIP6
- Previous models had to give up good simulation of mean state or good simulation of MJO but new models yield good simulations in both
- **Need to understand why CMIP6 models are improved in MJO simulations – comparison of CMIP5 and CMIP6 simulations to understand changes that led to improvements**
- Need to better understand what aspects of radiation, mean moisture, and coupled processes are important for MJO and its representations in models – model comparison using mechanism denial experiments
- Review paper to synthesize understanding of MJO and status of MJO modeling
- Why some models have a trade off between Kelvin waves and MJO?

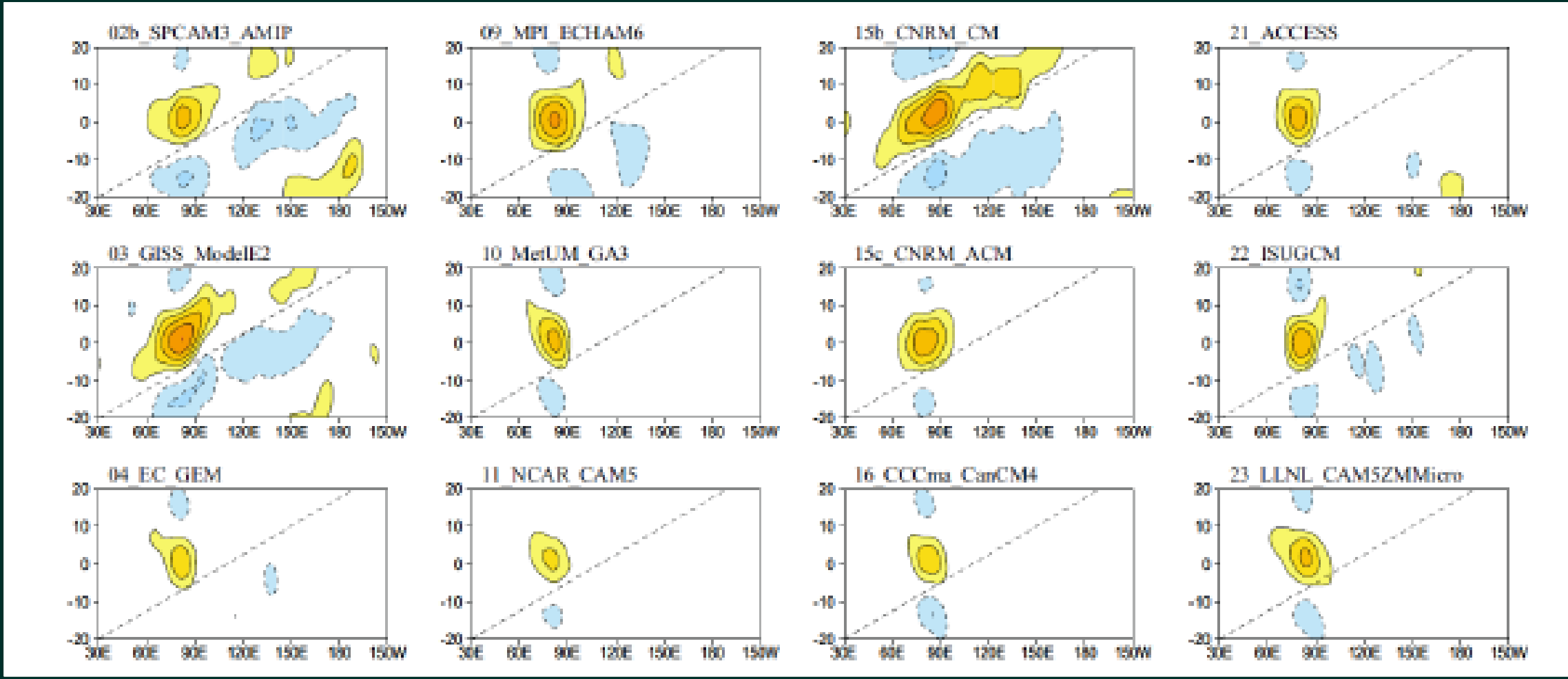


Selected models MJO (GASS/CMIP5)



Jiang et al (2015)

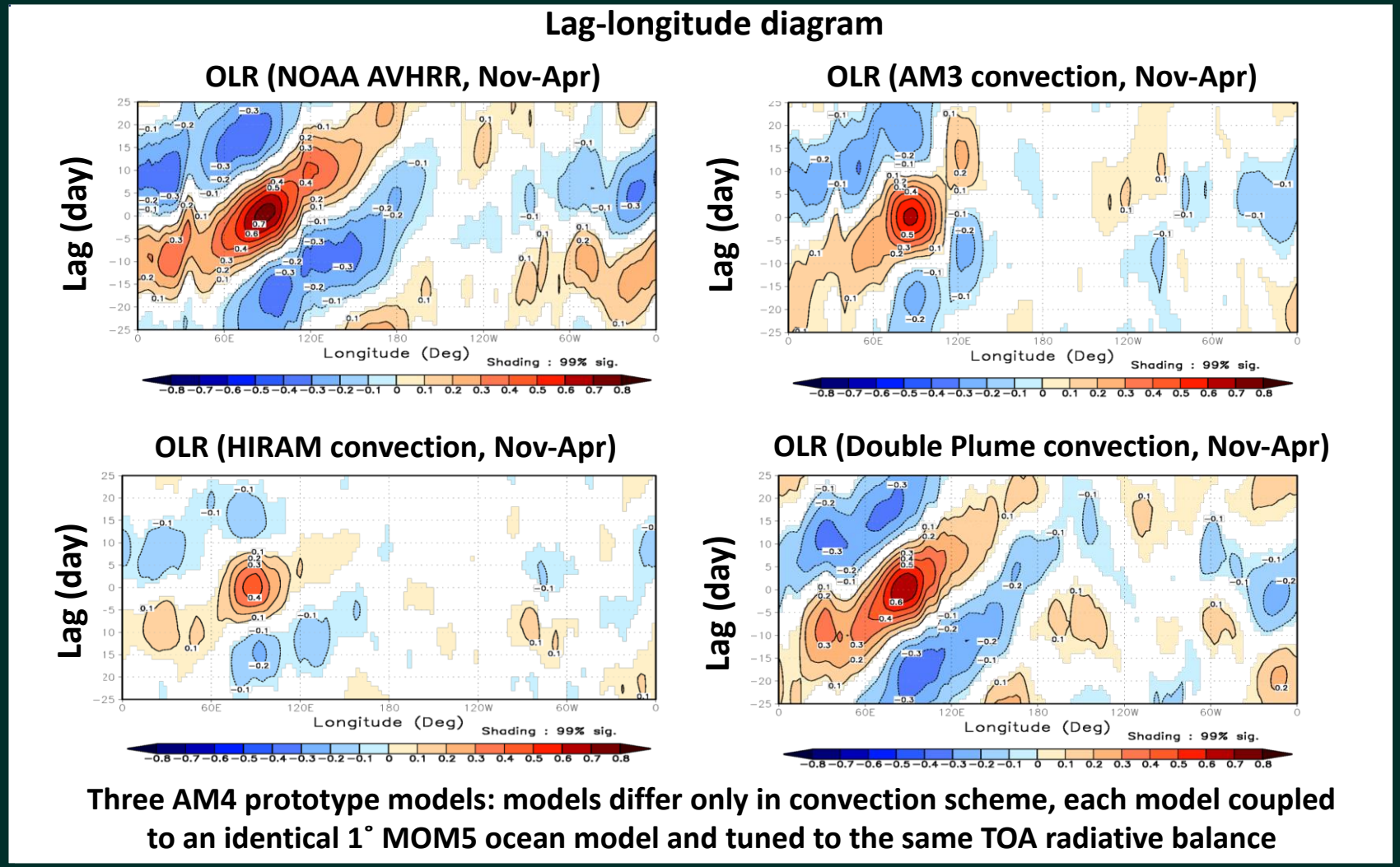
Selected models MJO (GASS/CMIP5) (cont.)



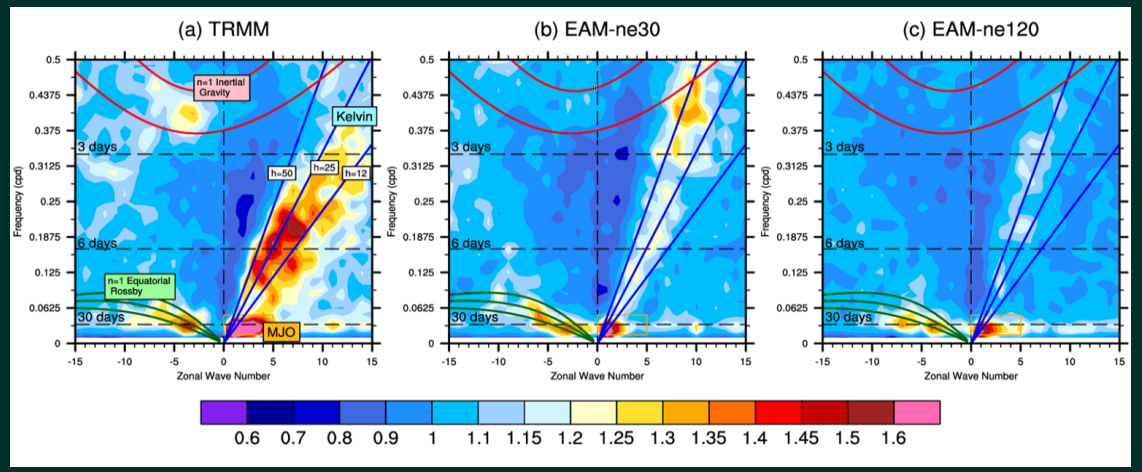
Jiang et al (2015)

Ming Zhao - MJO:

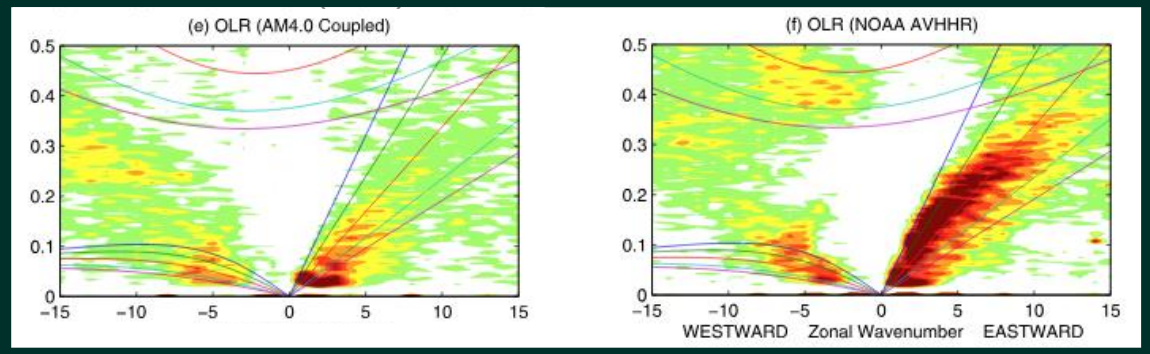
- MJO in GFDL model very sensitive to convection parameterizations
- Similar sensitivity in other models



Wheeler/Kiladis diagram examples for new models

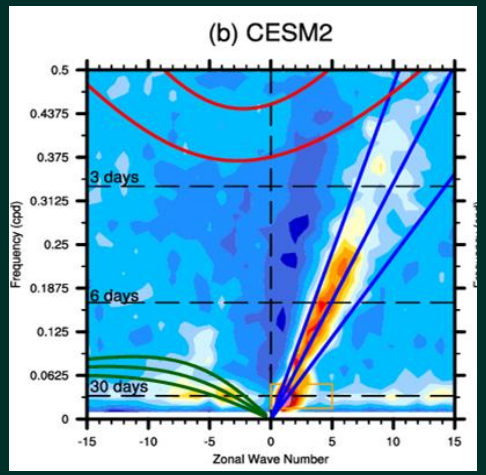


DOE E3SM

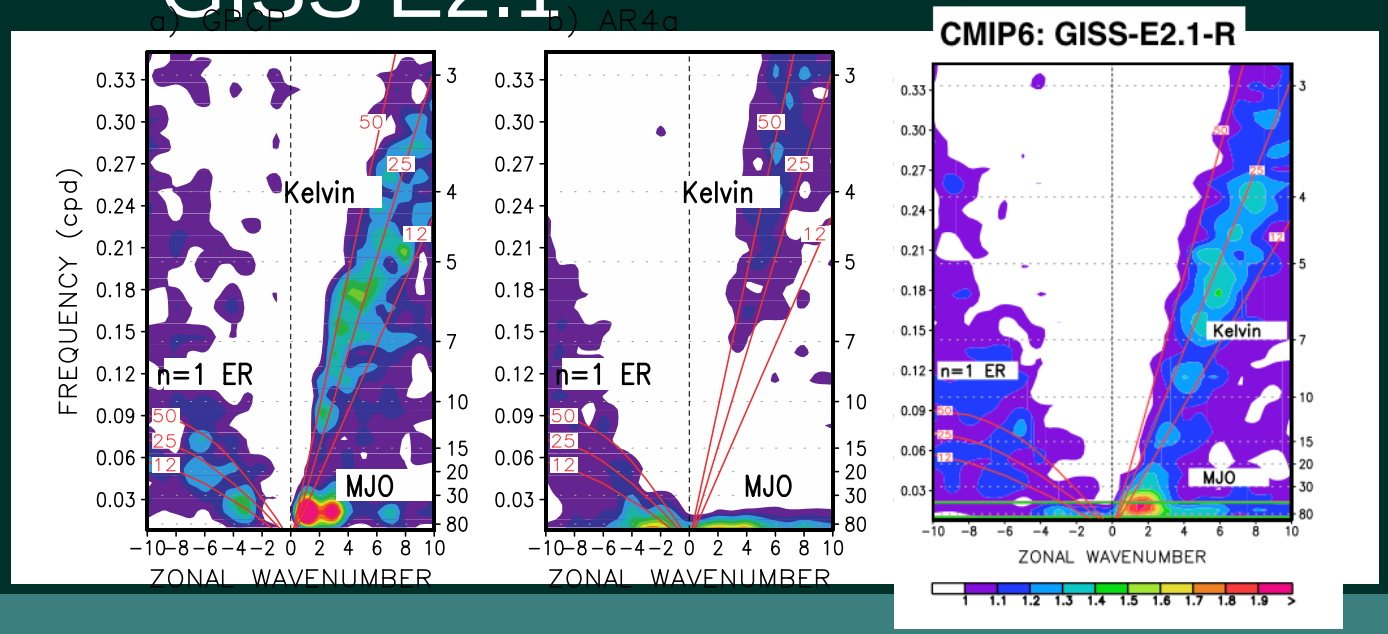


GFDL AM4

GISS E2.1

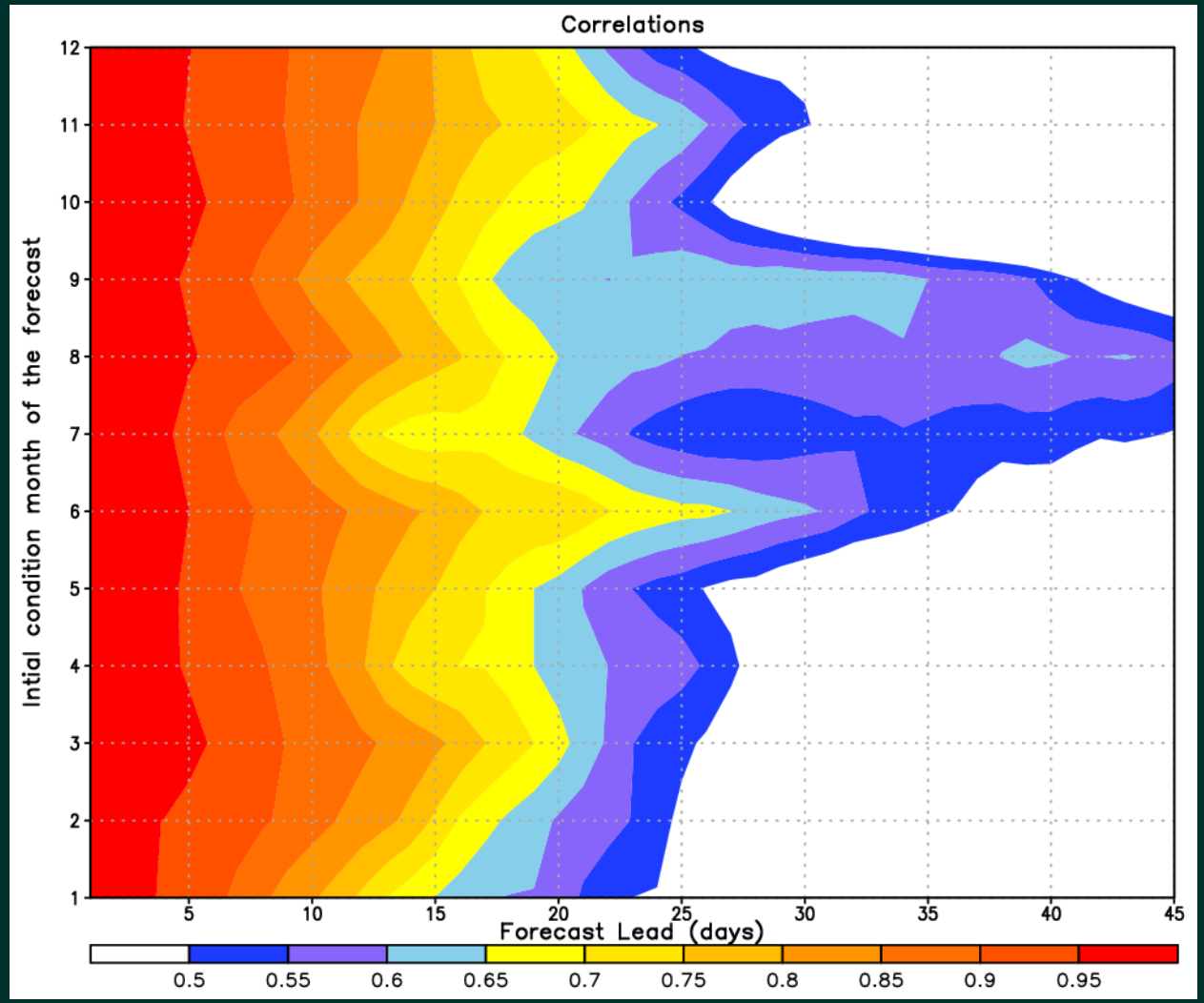


CESM2



Amin Dezfuli – MJO in MERRA2 S2S-v2

- MJO Correlations between MERRA-2 and SubX forecasts for various forecast lead days (x-axis), and different initial condition months of the forecast (y-axis).
- R > 0.75 at 15 days lead
- R > 0.65 at 20 days lead
- R > 0.55 at 25 days lead
- For longer leads, correlations are particularly high in June-September season (e.g., R > 0.5 at 40-day lead).



Potential for future work

- Importance of composition variation for QBO
- Interactions of QBO and NAO/ENSO/MJO
- Expansion of QBO-related diagnostics in standard metrics packages
- Need standardization of MJO diagnostics
- Sensitivity of modes to decadal (unforced) variability and climate change

Extra-tropical modes and teleconnections

Andrea Lang, described ENSO teleconnections in models, with some emphasis on stratospheric impacts on the troposphere, including effects of the QBO on modulating the teleconnections.

Siegfried Schubert demonstrated a subseasonal prediction technique using bias correction, based on MERRA-2 analysis increments, applied at model run time. Compared to prior results using a similar approach, this method is now showing promise, with improvements in: subseasonal modes in boreal summer, which are due to quasi-stationary Rossby waves guided by the subtropical jet; (b) interannual variations in boreal winter circulation and ENSO in the coupled system.

Jennifer Meixner described ongoing work to develop a coupled model in EMC, bridging the gap between GFS weather and CFC seasonal work. Testing involved sunning ensemble forecasts over seven years, and results indicate improvements in ENSO phases, the MJO, and sea-ice extent compared to their older models.

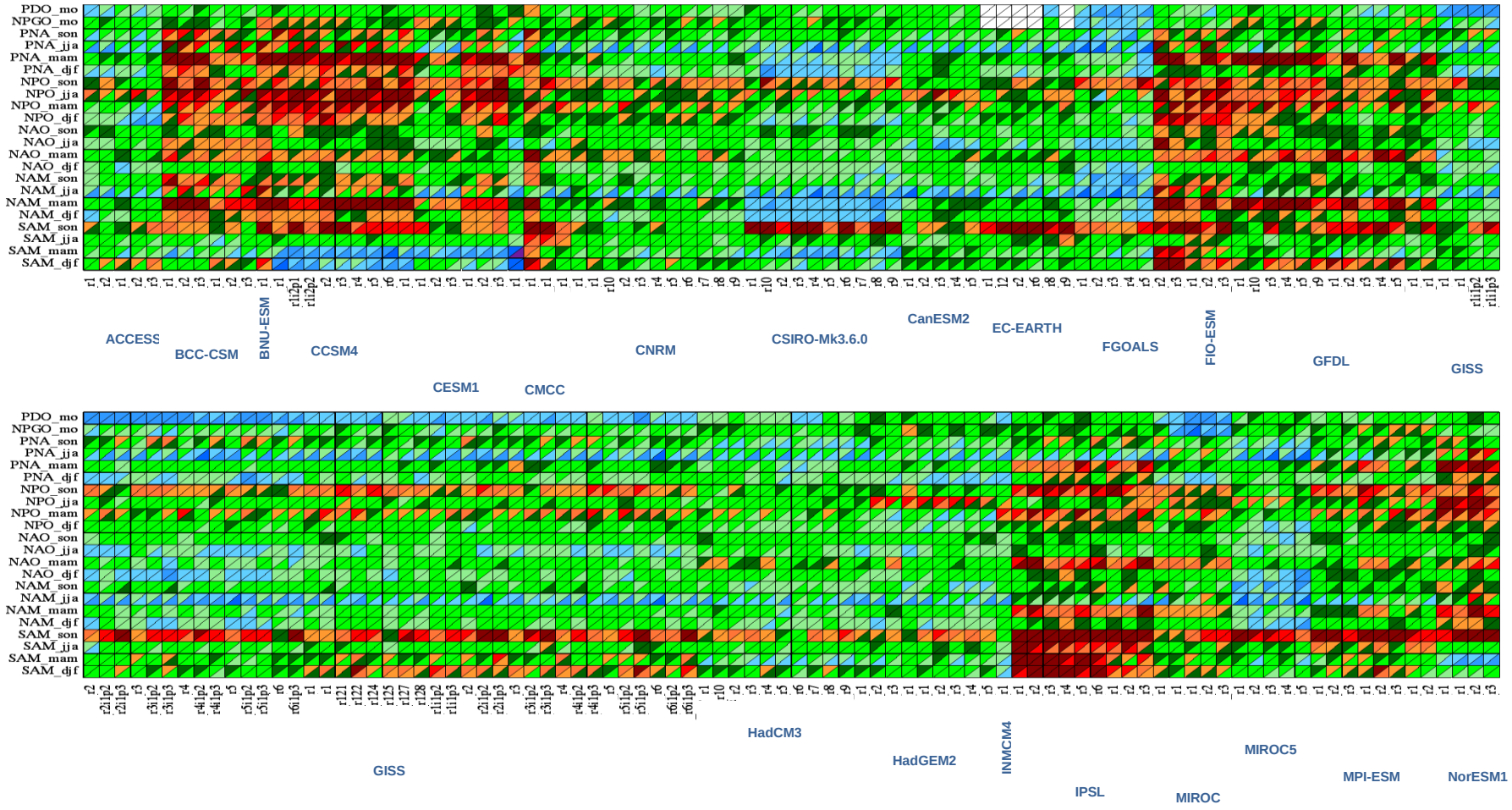
Nathaniel Johnson described the progress and challenges of S2S prediction of extratropical teleconnections at GFDL. SubX experiments with FLOR show the most predictable modes are in the northern hemisphere in DJF; ENSO, the Eurasian mode and NAO have predictive skill beyond five weeks

PCMDI Metrics Package for CMIP (Gleckler)

- Importance of robustness of observations
- Common Basis Function approach
- EOF mode swapping sometimes required

Amplitude ratios

Ratio of PC S.D.: Model/OBS



OBS1
20CR

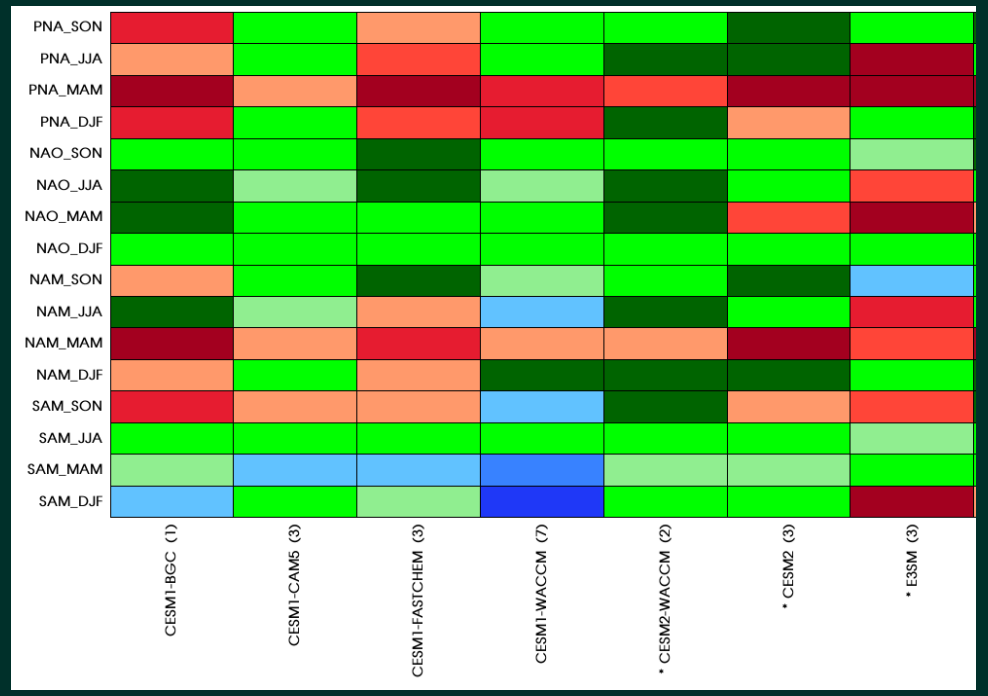
OBS2
ERA20C

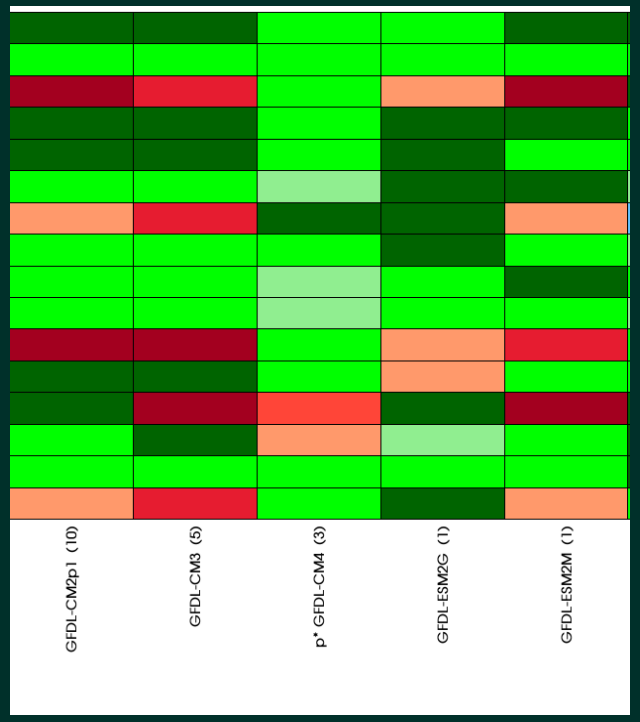
Overestimate

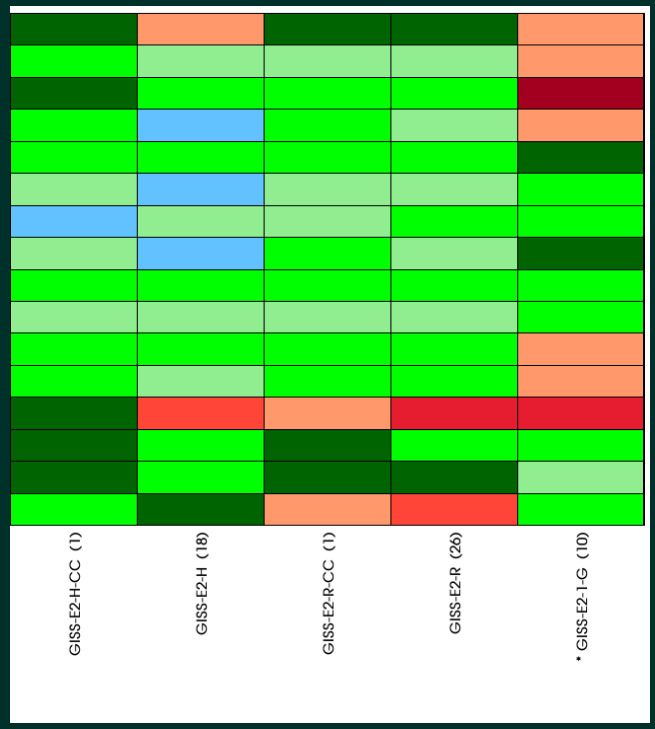
1.5
1.4
1.3
1.2
1.1
1.0 Good
0.9
0.8
0.7
0.6
0.5

Underestimate

CMIP6 improvements (?) in PNA/NAO/NAM/SAM







E3SM and CESM2

GFDL CM4

GISS E2.1-G

Climate Variability and Diagnostics Package (CVDP) (Fasullo)

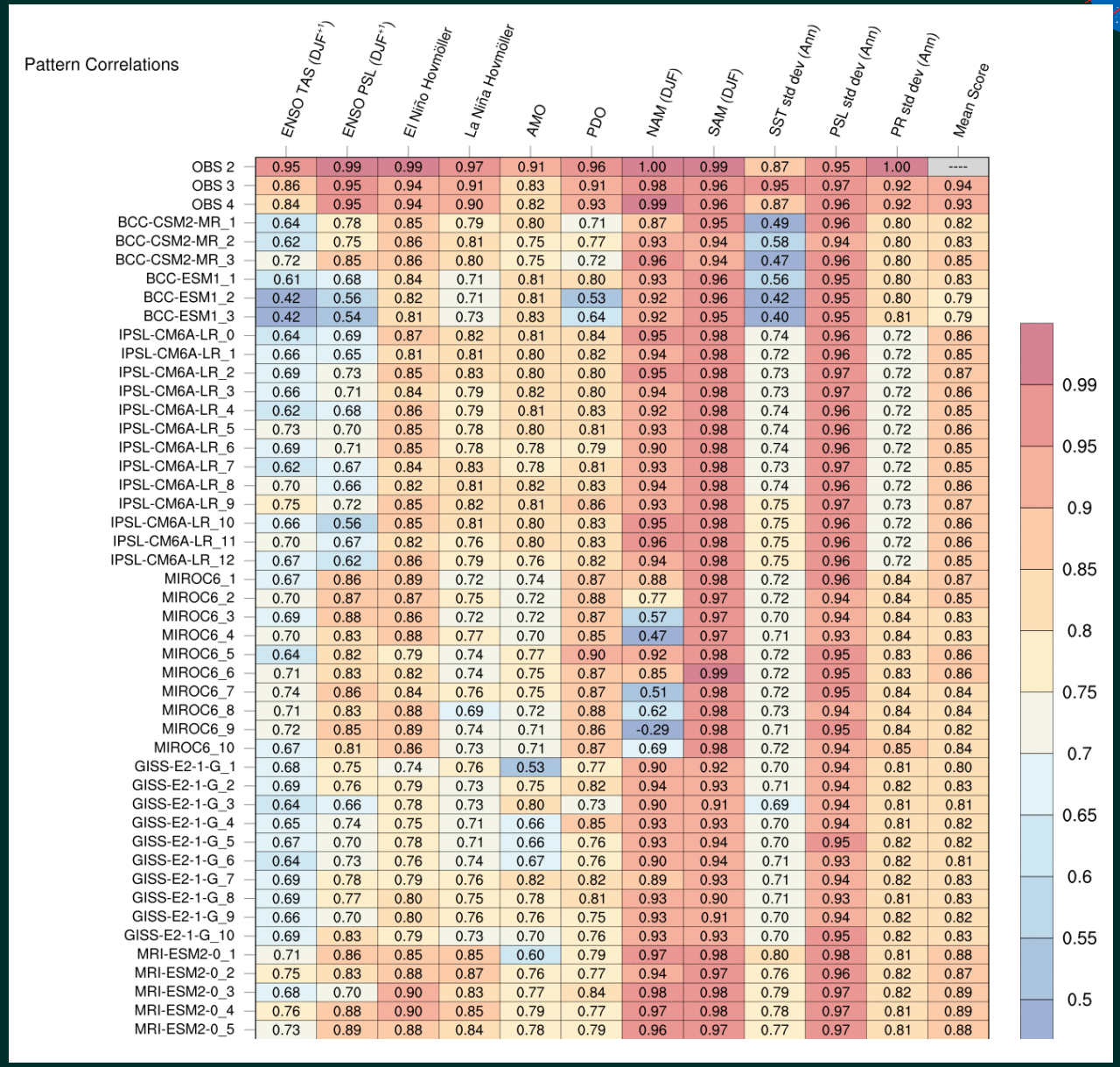
Software package for computing and scoring standard modes of internal variability in observations and models including:

- ENSO Composites (Deser et al. 2012)
- PDO (Mantua et al. 1997)
- IPO (Meehl et al. 2007)
- AMO (Trenberth and Shea 2006)
- NAM (Hurrell and Deser, 2009)
- SAM/PSA1/PSA2 (Thompson and Wallace 2000)

- http://www.cesm.ucar.edu/working_groups/CVC/cvdp/

CDVP Metrics table for CMIP6

- Pattern Correlations for ENSO, AMO, PDO, SAM, SST sd, PSL sd, PR sd



CDVP insights

- Importance of internal variability to set bounds of expected skill
- How long do runs need to be to have stable statistics?
- Systematic improvements in simulating ENSO/PDO across CMIP models are demonstrated in CVDP benchmarking
- CMAT-CVDP metrics suggest linkages between fidelity of the mean climate state and internal variability.

Other CMS business

- Continued concern across groups about new architectures for next-gen HPC and support for legacy codes
- New models w/high climate sensitivities discussed
- Ongoing interest among groups and IGIM in exploring Machine Learning/AI approaches in climate modeling – coordination of introductory talks for IGIM
- Specialized MIPs focused on ‘world avoided’ aerosol scenarios

Action items

- Rapid Response proposal (NASA, DOE, NOAA) to assess improvements in modes in new models (not just CMIP6)
- Taskforce for AI-related discussions established
- 2020 meeting will focus on aerosol/cloud interactions (chair S. Bauer)